The Diet Composition of Beaked Whales and Melon-Headed Whales from the North Pacific

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LONG-TERM GOALS

Knowledge of the diet of a species is crucial for understanding it's behavior and ecology, and also has relevance to assessing the impact of potential changes in behavior or spatial use that may be associated with anthropogenic activities. Assessing diet for many species of cetaceans is difficult, given that most foraging occurs far below the surface and that stomach contents of stranded animals are rarely available. Very little information on food habits of most species of beaked whales or of melon-headed whales (*Peponocephala electra*) is available from any region of the world.

This project proposes to describe the diet composition of several species of beaked whales and melon-headed whales in the North Pacific by conducting stomach content analysis of available specimens collected from stranded animals. Prey remains are now available from 26 beaked whales that represent six species. Additionally, stomach contents have been obtained from six stranded melon-headed whales in Hawaii. The identification of each prey item to the species level and size and mass estimates of prey will allow for a detailed description and comparison of diet composition as well as provide insight into the foraging behavior and ecology of these whales in the North Pacific.

OBJECTIVES

The first component of this overall project involves describing the diet composition of melon-headed whales from the Hawaiian Islands. All data collection and data analysis related to this portion of the project is complete and this report focuses on summarizing the progress towards this objective.

The second project objective is to describe the diet composition of beaked whales in the North Pacific. Over the project duration stomach contents from two additional beaked whales were collected during separate stranding events in Guam for inclusion in this project. One of these strandings occurred in March of 2015 and identification of the stomach contents from this Cuvier's beaked whale is currently underway and will add another sample to the original stomach content samples available for this study. The preliminary sort of the contents from the adult male that stranded in Guam in March of 2015 indicate the presence of deep water, mesopelagic cephaolopods, fish and shrimp in the sample. There were a high number of deep water shrimp present in this stomach of this beaked whale. The other stranding in Guam occurred in July of 2015, representing another adult male Cuvier's beaked whale. Stomach contents that included cephalopod beaks were collected from this whale and are currently frozen in Guam. This sample is scheduled to be hand carried by Honolulu NOAA staff that is currently in Guam upon return to Honolulu in early October of 2015. Inclusion of the July 2015 Guam beaked whale will total 26 available beaked whale stomachs from the North Pacific for contribution to this study.

BACKGROUND

Although melon-headed whales are a poorly-known species, there is more known about melon-headed whales in Hawaiian waters than anywhere else in the world (Aschettino et al. 2012; Woodworth et al. 2012). This species is thought to be sensitive to underwater sounds. In 2004, 150 melon-headed whales demonstrated pre-stranding behavior in Hanalei Bay, Kauai, which coincided temporally and spatially with a RIMPAC (Rim of the Pacific) training exercise (Southall et al. 2006). In 2008 approximately 100 melon-headed whales moved into a shallow water lagoon system in Madagascar, with many subsequently stranding, coincident with the use of a high-power mid-frequency multi-beam echosounder used in mapping offshore of the stranding site. The multi-beam echosounder was thought to be the most likely behavioral trigger for the animals entering the lagoon system (Southall et al. 2013).

Despite their distribution throughout the tropics and sub-tropics world-wide, there is no study dedicated to the food habits of this species in the published literature. All that is known of melon-headed whale diet comes from the stomach contents of individual specimens in Hawaii and South Africa and unpublished data from a mass stranding in Brazil (Barros, unpublished, Best and Shaughnessy, 1981; Clarke and Young, 1998; Sekiguchi et al. 1992). An examination of the food habitats of melon-headed whales from any region of the world would be a valuable contribution to furthering our understanding of the foraging behavior of this species. Such an examination of food habits from Hawaiian melon-headed whales would be especially relevant in light of the 2004 mass stranding behavior and the continued importance of Hawaiian waters to naval training exercises.

APPROACH

Stomach contents were collected from five melon-headed whales that stranded between 2009 and 2013 in the main Hawaiian Islands and from one individual that stranded in 1985. In all but one case,

melon-headed whales were identified to species based on body length, black coloration, head shape and pointed pectoral fins. For the Kaupoa, Molokai individual, genetic analyses performed by the Southwest Fisheries Science Center was necessary to confirm the species identification but it was not possible to obtain sex due to tissue degradation. Based on stranding locations these individuals were likely members of the Hawaiian Islands population, that moves among islands and offshore, rather than the Kohala resident population (Aschettino et al. 2012; Carretta et al. 2014). The Waiehu, Maui individual dorsal fin profile was matched to the Cascadia Research Collective photo-identification catalog. This individual (HIPe0603) had previously been sighted three times since first being identified in 2004 near the Big Island but was part of the Main Hawaiian Islands population, and not the Kohala resident population.

Stomach contents were initially frozen for five of the melon-headed whales. The otoliths were removed and stored dry in gel caps prior to the cephalopod and fish bones being fixed in formalin for one of the whales. Frozen contents were later thawed and each sample was then rinsed through a progression of sieves with decreasing mesh sizes of 1.4 mm, 0.94 mm and 0.50 mm. After sorting, cephalopod beaks and fish bones were preserved in 70% ethanol. Fish otoliths were stored dry in gelatin capsules. All remains were identified to the lowest possible taxon using the private reference collection of W.A. Walker and the fish bone, otolith and cephalopod beak reference collections housed at the National Marine Mammal Laboratory (NMML), Seattle, Washington. A voucher series of select beaks and otoliths representing each prey taxon were removed from the individual stomach samples and incorporated into the NMML reference collections. The remainder of the individual stomach samples were stored in alcohol at NMML.

The total number of each species of cephalopod was estimated as the number of lower beaks present. The total number of each fish species was estimated based on the greater number of left and right otoliths. In a few instances the number of fish prey was estimated based on the greater number of left or right paired cranial bones. Dorsal mantle length and total weights were estimated by measuring lower beak rostral length for the cephalopod decapods and lower beak hood length for the cephalopod octopods and then applying the appropriate regression equations. Cephalopod beaks were measured to the nearest 0.1 mm with either an optical micrometer or, in the case of large beaks, Vernier calipers. In most cases, regression equations from Clarke (1986) were used to estimate prey size and mass for the cephalopod species present. If no regression equations were available from Clarke (1986), prey sizes for these species were estimated using data from individuals of near equivalent beak size housed in the NMML reference collection. If available in Clarke (1986), pigmentation (darkening) of the wing portions of the lower beak were recorded for the beaks. Beaks were considered to be from adult squid when the wing pigmentation was complete. Fish otoliths and diagnostic bones were measured to the nearest 0.1 mm using an optical micrometer. In most cases, fish prey standard lengths and weights were estimated using regression equations from the literature (Ohizumi et al. 2001, Spear et al. 2007), or from regressions developed for similar, closely related species at NMML. In instances where appropriate weight regressions were unavailable, weight was estimated by comparison with other closely related species of similar size.

WORK COMPLETED

Stomach content remains from the six melon-headed whales have been thawed, rinsed, sorted and processed for identification. All remains from the six whales have been identified to the lowest possible taxon using the private reference collection of W.A. Walker and the NMML fish bone, otolith and cephalopod beak reference collections. Cephalopod beaks were measured to the nearest 0.1 mm

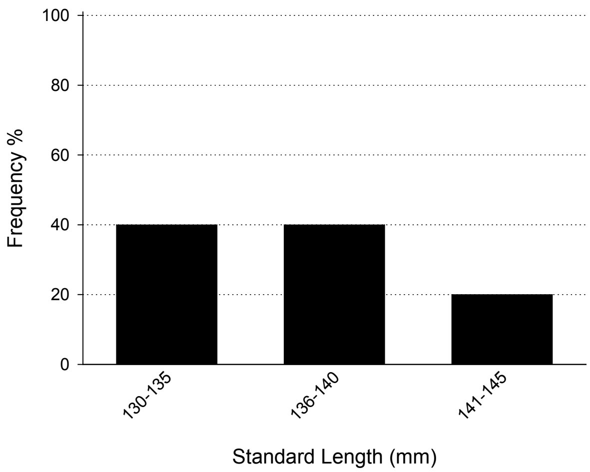
with either an optical micrometer or Vernier calipers. Fish otoliths and diagnostic bones have also been measured to the nearest 0.1 mm using an optical micrometer. Prey remains have been tabulated for each of the individual whales as well as for all six whales together. The contribution by abundance of each prey species to melon-headed whale diet composition in Hawaii has been tabulated and examined. Wing pigmentation has been examined to distinguish juvenile and adult squid. Species specific regression equations have been applied in order to also estimate prey size. Prey size estimates have been used to calculate the dietary contribution by mass of the prey items identified in the stomachs. Dietary contribution by abundance and mass of prey items has been compared and figures created to illustrate findings from this work.

RESULTS

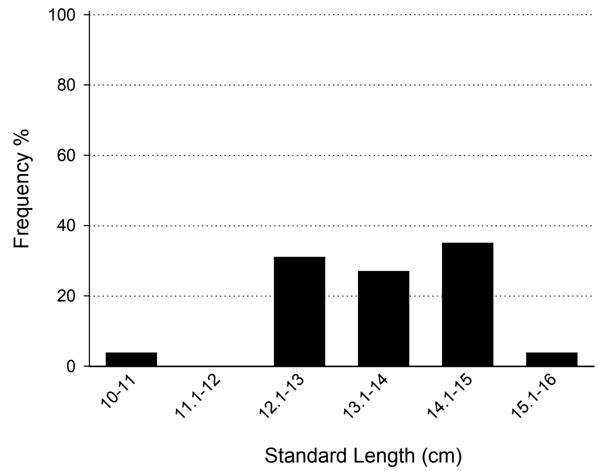
Together, the six stomachs contained 315 food items ranging from 2-146 items per stomach. Three contained only cephalopods and three contained both cephalopods and fish. Relative frequency both by number and occurrence indicated that 50% of the diet is comprised of fishes and 50% of cephalopods. However, when estimating prey contribution by mass, 75% is comprised of cephalopods and only 25% fishes.

Fish remains represented 9 families and 24 species. Myctophid lanternfishes were the most abundant fishes with 35.6% of the total prey by number but only 11.1% by mass. Of these, the most abundant species were *Lampadena urophaos* (14.9%) with lengths ranging between 10.5 and 15.1 cm, *Lampanyctus nobilis* (6.7%) with lengths varying between 133.4 and 142.7 mm and *Diaphus fragilis* (4.4%) with lengths between 99.4 and 121.9 mm (Figure 1). By number, the fish family Stomiidae represented 6.7% of the prey with a contribution by mass of 9.3%. The family Stomiidae was primarily represented by the species *Chauliodus macouni,* which accounted for 6.0% of the prey by number and 8.0% by mass (Figure 1).

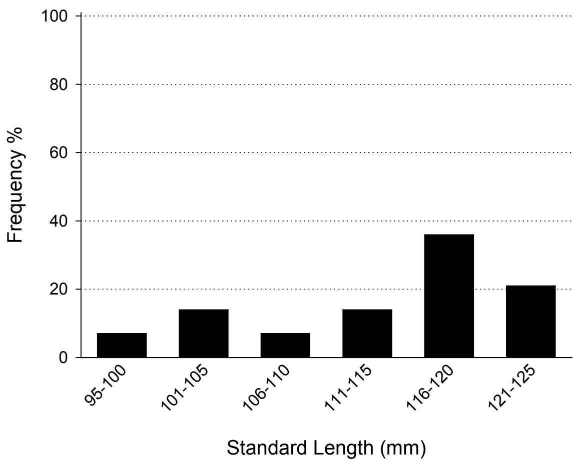
A total of 158 lower beaks were identified representing 15 families and 26 species of cephalopods. The highest contribution of cephalopod prey by weight was represented by the Enoploteuthidae family (19%). Enoploteuthid squid were present in five of the six stomachs examined and represented 13% of the prey contribution by number. Within this family, *Enoploteuthis reticulata* adults with estimated dorsal mantle lengths ranging between 99 and 146 mm represented 8.8% of the contribution by mass and 3.8% by number. The Cyloteuthidae family represented 10% of the prey contribution by mass and 7.7% by number and was represented in only two of the six stomachs examined. Twenty-one *Cycloteuthis sirventi* juveniles were present in one of the stomachs, accounting for 8.2% of the mass contribution in the Cyloteuthidae family. All were juveniles with estimated dorsal mantle lengths ranging between 99 and 136 mm. A single diamond squid, *Thysanoteuthis rhombus*, was found in one of the melon-headed whale stomachs and accounted for 11% of the total prey mass. An unknown species of onychoteuthid, *Onychoteuthis sp*., was present in five of the six stomachs examined but contributed only 4.4% by mass and 3.8% by number. With the exception of the Enoplotheuthidae and Onychoteuthidae families, no other cephalopod families were represented in more than half of the stomachs examined.



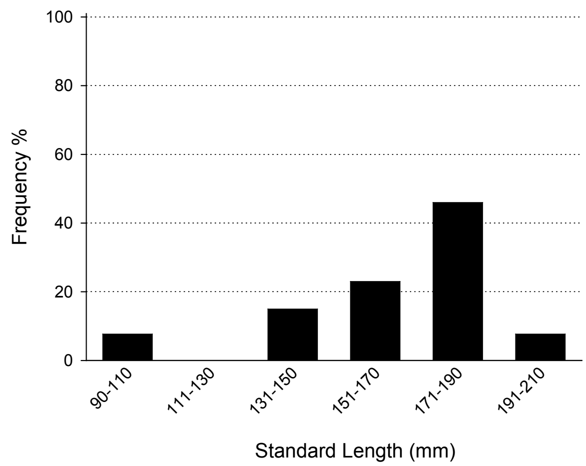
LAMPANYCTUS NOBILIS



LAMPADENA UROPHAOS



DIAPHUS FRAGILIS



CHAULIODUS MACOUNI

Figure 1) Prey size estimates of the fish species most frequent by number among the six melon-headed whale stomachs examined.

IMPACT/APPLICATIONS

The prey of Hawaiian melon-headed whales consists of 50 different prey species that represent a wide diversity of cephalopods and fish. When considering prey by number, the contribution of cephalopods and fish are equally represented in the Hawaiian whales, but fish were only present in half of the stomachs examined while cephalopod prey was present in all stomachs. Additionally, when estimating the prey contribution by mass, 75% of the diet is comprised of cephalopods and only 25% fishes, which suggests that when melon-headed whales prey on fish, they are of a large number but small size. For example the most abundant species of fish, *Lampadena urophaos*, were only 10-15 cm in size. A minimum of 47 individuals were found in only 2 of the whale stomachs, accounting for a greater contribution by number (14.9%) compared to only 3.7% by mass.

Fish presence among the stomachs was dominated by various species of lanternfishes. Myctophids were represented in two of the three stomachs that had fish remains with 15 different species represented among the two stomachs. Lanternfishes typically undergo diel vertical migrations and are found at greater depths during the day than at night. Hawaiian trawl data indicates significantly deeper daytime depths for the three most abundant species of lanternfishes present in the stomachs. In the Hawaiian Islands, *Diaphus fragilis* is found at depths of 520 – 600 m during the day but in only 15-125 m at night (Mundy, 2005). *Lampadena urophaos* is found in waters as shallow as 95 m at night but at a minimum depth of 500 m during the day (Reid et al. 1991; Clark, 1973) and *Lampadena nobilis* is found in less than 150 m depths at night compared to daytime depths near 500 m (Mundy, 2005). It is unknown at what depth melon-headed whales are ingesting lanternfish prey, but it is possible that foraging by melon-headed whales occurs during the nighttime at the relatively shallower depths.

A wide diversity of cephalopods comprises the majority of the diet of Hawaiian melon-headed whales when considering prey contribution by mass. Prey identification from the six Hawaiian melon-headed whales was compared to the only prior study that examined the diet of an individual melon-headed whale in Hawaii. A comparison of our findings to this prior study where only six lower beaks were present suggests that the diet of Hawaiian melon-headed whales is even more diverse than our report of 50 species of fish and cephalopods among the six stomachs. The family Bathyteuthidae and the genus *Teuthowenia* were not among the prey remains identified in the current study but were previously reported in a stranded melon-headed whale from Hawaii (Clarke and Young, 1998). It is often difficult to infer the foraging depth of predators from cephalopod prey remains as most cephalopods undergo diel migrations (Roper and Young 1975). Prey depth of the families with the greatest frequency by number of cephalopods in our sample, Enoploteuthidae and Cyclothuthidae, indicate that both families are typically found between 300 and 600 m during the day and in the upper 200 m at night (Roper and Young, 1975). The depth data available from the high diversity of cephalopods and fishes found in our samples suggest that the deep scattering layer comprises important prey to Hawaiian melon-headed whales and that this species feeds in the epipelagic and mesopelagic zones.

The 2004 mass stranding behavior in Kauai and the 2008 Madagascar event strongly suggest that melon-headed whales are vulnerable to anthropogenic noise. Similar to the concern with beaked whales, the displacement of individuals out of their normal habitat for extended periods can lead to secondary factors such as emaciation and dehydration that result in a lethal stranding event (Southall et al. 2013). Our work provides fundamental knowledge on the prey items fed upon by melon-headed whales and provides insight into their activity at depth. This is the first study of the food habits of melon-headed whales from any region of the world and will aid in our understanding of both the basic biology of the species as well as in assessing the impact of activities that have the potential to result in habitat displacement of whales.

RELATED PROJECTS

There are no related projects.

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